

CRISTIAN- RADU    STAICU

AN ASTRONOMICAL INTERPRETATION OF DATA FROM THE  
SANCTUARIES   OF SARMIZEGETUSA REGIA

BUCUREȘTI

2016

- 1. Introduction*
- 2. Rules to be followed in order to obtain a plausible theory*
- 3. The selection of sanctuaries*
- 4. The 7th sanctuary: a mathematical model for a eight-year calendar*
- 5. The greater circular sanctuary - a general view*
- 6. An astronomical model for data regarding the Sun*
- 7. Some astronomical data regarding the Moon. The estimated construction date*
- 8. The mathematical model for short and medium periods of time*
- 9. The mathematical model for long and very long periods of time*
- 10. The meaning and value of the results*

## 1. Introduction.

An abundant literature was issued referring to the subject of Dacian calendar. The points of view, approaches and solutions extend on a very wide scale of value - from sustainable scientific hypotheses to urban legends. It is completely understandable the affective components of some theses. Therefore, my goal in this paper is not to blame one or another of the authors or the solutions they have devised until now - as strange as those results may be - but to open to research some new directions and fields of interpretation. Also, general public must have the opportunity to understand what are the exact limits of our knowledge at this moment regarding the problem of Dacian sanctuaries and the rules the scientific work enforces upon researchers.

The first scientist to suppose an architectural representation of the Dacian calendar in the great sanctuary of Sarmizegetusa was D. M. Teodorescu, but the real study begun with the papers of acad. Constantin Daicoviciu and Georges Charrière<sup>1</sup>. The problem is difficult in many ways:

- the ancient information is limited to the sayings of bishop Jordanes;
- the archaeological discoveries have an element of pure chance and can change completely the data, thence the mathematical approach, as it happened when the 68 pillars of the third circle proved to be in fact 84;
- the archaeological data are not available as a systematic corpus, or at least in a detailed form; as consequence the debate uses out of date sketches and references<sup>2</sup>.

---

<sup>1</sup> See *Enciclopedia arheologiei și istoriei vechi a României*, Editura Enciclopedică, București, 1994, vol. 1, quoted as EAIVR, s.v. *calendar*, pp. 236 - 239. Teodorescu argued for a 28 days cycle.

<sup>2</sup> Acad. Al. Vulpe argues: "*As far as the as the archaeological monuments are concerned is necessary to entirely and correctly publish the results of any archaeological diggings*"- see Al.

We have to choose between two attitudes:

- 1. To consider that there are no sufficient indications about the level of astronomical knowledge of our ancestors, lesser even about any materialization in architectural form, and, to avoid generating a pseudo-mythology, to reject the mere possibility of a calendar;
- 2. To admit that there are facts that must be considered, even when they are conflicting, hard to identify and to understand. If we argue with no peremptory or preconceived ideas, having always in mind that we discuss only working suppositions, we may obtain valuable results.

Obviously, this is my standpoint. We are not in a situation that "*THE SOLUTION*" may be presented, far from that, but I consider that progress will be made if we accumulate scientific hypotheses, consistent with the now known level of Dacian civilization, as a base to find new directions in interpretation and as a criterion to evaluate what worth to be saved from the previous theories.

As I stated before, I have no intention to engage in polemics or to blame. I consider that the reader knows the main data accumulated until now; from these, I selected the ones with potential value and I created a simpler, thence more practical, mathematical system.

## 2. Rules to be followed in order to obtain a plausible theory.

Archaeological findings are open to interpretation, if we do not have a written source to guide us; we have to establish rules in order to obtain *plausible* suppositions from them.

I underline the word "plausible" because a hypothesis is first and foremost a form to order a puzzle of data that can or cannot be in relation with one another. To become *truth* it must be somehow tested and proved as a fact: if it verifies, we don't consider the respective assertion to be a supposition any longer.

---

Vulpe, *Spirituality of the Getae and Dacians*, an introduction to David Reu's book *The Dacian Stones Can Count* - bilingual edition, Bucharest, 2011, p. 9. It must be remarked the manifest reserve of the distinguished scientist in the matter of mathematical fancies solutions.

The first rule applies to all problems: the arguments used must be *logical*, consistent with the facts. One must not argue - as had been the case - that the precession "change the cardinal points", or to speak about Sumerians as Indo-Europeans surviving the Ice Age.

The second rule is that of flexibility. The theory must allow us to add or to remove a limited number of elements, without major repercussions on the consistency of the hypothesis.

That is the principal reason of objecting to put all Dacian sanctuaries in the same mathematical model: if only one of them is invalidated, the whole theory lose foundation; therefore we must select carefully the temples the calendar model is based on. We must take into consideration an evolution in - at least - two dimensions :

- from Burebista and Decaeneus to Decebal is a relatively long period of time (80 BC - 86 AD), and the religious concepts undoubtedly evolved, the text of Strabon (VII,3,11) being an indirect proof of this spiritual change at its starting point;
- the architectural complexity of the sanctuaries and the craftsmanship of their builders have evidently increased, so we cannot presume that in the earlier temples are the same and as many astronomical data as in 1st century AD.

The third rule is an imperative one: we must not establish from the start what results we should obtain through calculus, not even their type; that is a very common mistake of the previous models. The values may easily be organized in such way that one may "force" them to confirm the wishes of the author but it would be an error of judgment.

There must be a strong logic in assuming a time value for a construction element in a temple. The experience accumulated up to date is useful to avoid repeating errors:

- we cannot suppose fractional values; all the values must be "natural numbers"(=whole and positive numbers);

- the use of this values must be consistent: the same element must represent always the same duration;
- if exceptions to this rule are unavoidable, they must be as few as possible and they must be thoroughly explained.

The results should be compatible with the 1st century knowledge and should allow comparison with other cultures.

### 3.The selection of sanctuaries.

We must start from the fact that, even if we use often the terms "sanctuary" and "temple", there are not firm evidences of what or which are the Dacian sacred places. It was, and still remains, a hypothetical identification of the great monuments found at Sarmizegetusa - Grădiștea Muncelului through comparison with other civilizations. Similar construction were found later and are currently documented all over the country.

There are no cult objects found inside these monuments at Sarmizegetusa, with the exception of a clay medallion representing a goddess<sup>3</sup>. It was retrieved in the basement of the 1st Sanctuary and most probably it was a construction offering.

The building named "The ancient greater quadrilateral sanctuary/ the 1st sanctuary" has a troubled history and the reconstruction attempts are founded on preconceived ideas<sup>4</sup>.

I think that we must understand first how the building was destroyed, then to reconstruct the original.

Most probably the water source contiguous with one of the smaller sides<sup>5</sup> permeated the basement for a long period. That side collapsed letting out into the open eight plinths made from limestone, representing two rows from the total of

---

<sup>3</sup> The image came from a Roman coin, minted in 80 BC, representing Diana; the opinion that in Dacia probably it was interpreted as Bendis was rejected in EAIVR, vol. 1, s.v. *Bendis*.

<sup>4</sup> E.g. Ion-Horațiu Crișan, *Burebista și epoca sa*, Editura științifică și enciclopedică, București, 1977; idem, *Spiritualitatea geto-dacilor. Repere istorice*, București, 1986. The roof devised there is an equilateral triangle too high to resist any strong wind.

<sup>5</sup> The side is situated roughly towards NNE; the entrance was most probably on the grater façade, from the main street of the city.

15 x 4=60. The plinths have obvious signs of mechanical abrasion. The core of the debate is that: what were the columns made of? The usual answer is limestone but only one such column was found in all the area, and it not belongs to this building. Also was no mention whatsoever of marks that could indicate how the pieces of columns - either of limestone or andesite - held together.

Therefore is much simpler to consider a model that is based on the usual pattern of the Dacian wall structure, used in all fortifications since Ist. century BC:

There were 60 wooden columns on limestone plinths. Wooden beams held the columns together and a deep layer of emplekton fastened their bases, covering the plinths. What we may see today is a ground floor or a cellar; very likely it existed a main floor that supported the roof but we do not have any evidence of it, except the comparison with the second sanctuary.

The water infiltrations made the smaller side crumble, the columns turned clockwise and that caused the abrasion of the plinths. Eight of the columns were lost in the precipice nearby, nevertheless the soil was consolidated in the remaining parts. That surface, a flight of stairs on the undamaged small side and seven from the ancient plinths will be used to build the 2nd Sanctuary. It was a construction with seven columns sustaining the roof: there is no doubt that the columns were intentionally placed *between* the previous rows, on consolidated ground.

There were made some attempts to find parallels to these two successive buildings among the hellenistic *temples*; actually they have striking similarities only with the northern portico / *stoa* of the agora in Cyrene<sup>6</sup>. Therefore I consider that we have two civilian constructions, because it would be somewhat unusual that an initially sacred place became later a secular one.

I must emphasize too that a temple can be build on the foundations of a previous construction.

The circular sanctuaries are now in a greater number than a few decades ago but the debate concerning their role is still open in most cases. A consensus exists nevertheless about the sacred character of the monuments found at Brad, Pecica,

---

<sup>6</sup> See Fr. Chamoux, *Civilizația elenistică*, Editura Meridiane, București, 1985, vol. I, pp.407-408, fig. 17; the drawing and reconstruction by S. Stucchi.

Racoș și Sarmizegetusa. Unfortunately, the three first are very damaged and all considerations that can be made about astronomical and temporal data are only speculations; we deplore especially the state of the great temple in Racoș.

It is very difficult to prove a line of evolution from the quadrilateral sanctuaries in Costești, through the simple ring found in Pecica to a more elaborated structure manifest in Racoș, and finally to attain its maximum of complexity in the two circular sanctuaries in Sarmizegetusa. The excavation in Brad showed that an absidal construction was built on the remains of a quadrilateral edifice, only to be replaced later by the circular temple.

Any attempt to build a theory about the three temples is hazardous at this point, because there are too many unknown factors and variables to consider. This is the reason that made me limit the following study only to the 6th and 7th sanctuaries in Sarmizegetusa.

It must be noted that the 6th and 7th Sanctuaries, together with the altar called "the andesite Sun", were intended from the beginning as an architectural unit.

#### 4. The 7th sanctuary: a mathematical model for a eight-year calendar.

The seventh sanctuary - also known as "the smaller circular sanctuary" - can be seen today as a ring of andesite pillars 12.5 m (=41 ft) in diameter. An interior wooden structure with tile roof was destroyed since ancient times, most probably during the Traian's wars (101 -106 AD).

The remaining part consists of 13 groups of thinner and taller pillars<sup>7</sup>, isolated through 13 wider and shorter andesite blocks. The thinner pillars succeed clockwise as follows, beginning in NNE:

6 - 8 - 8 - 8 - 7 - 8 - 8 - 8 - 8 - 8 - 8 - 8 - 8 -                      (- stands for wider blocks)

1st series

2nd series

---

<sup>7</sup> They have a tenon and their total height, when intact, is about 110 cm; the blocks are roughly half in height. The andesite pillars in the 6th sanctuary are of similar shape.

It is accepted now that the choice of numbers 6, 7 and 8 is based on the belief they have some kind of magical power. These numbers can be found, in groups of objects and in the display of columns in buildings, all over Dacia; e.g.: Bunești - 6 objects; Buridava/Ocnița - 8 rush lights; Poiana Dulcești - Varnița - 7 mugs; Costești - constructions/temples with 6 x 6 and 6 x 7 rows of columns.

The central structure being destroyed, the part presumably bearing astronomical data, the only possible discussion is about the significance of extant data as representing a calendar.

We observe that the groups of eight pillars are separated in two series by the groups of 6 and 7 pillars, therefore the two parts cannot have the same meaning: their periods must be different.

Let us consider the simplest mathematical model possible:

- for the groups of 6 pillars in the grater circular sanctuary, C. Daicoviciu și G. Charrière have admitted the equivalence 1 pillar = 1 day. The hypothesis was largely accepted and the period was even named "sextimana" or "the Dacian week", so we may see in the same way the corresponding group in the seventh sanctuary.

- let it be that in the group of 7 elements the unit represents a "sextimana" and therefore the entire group represents  $6 \times 7 = 42$  days;

- following the same logic, the groups in the second series of 8 pillars equal each  $6 \times 7 \times 8 = 336$  days.

Obviously, if we consider the pillars from the first series of 8 as 1 pillar = 1 day we have a total of

$$(6 \times 7 \times 8) + (8 + 8 + 8) = 336 + 24 = 360 \text{ days}$$

The conclusion is that each group of 8 elements in the second serie represents a year, and the serie as such stands for 8 years.

After 8 julian years the time difference would be

$$(8 \times 365,25 \text{ z}) - (8 \times 360 \text{ z}) = 2922 - 2880 = 42 \text{ days}$$

and could be corrected by adding a period of 42 days at the end of the cycle. There is no pillar to be marked in the second series because *the calendar is in advance*.

This was only a rough form of the model. We may improve it: instead of 7 years of 360 days and one of 402 days, we should have easily 7 years of 366 days and one of 360 days, by adding a "sextimana" in all but last. As in previous case, nor this period of 6, nor the 3 of 8 days in the first series are marked in superior groups *because they are epagomenae*.

So a rule can be established: *the epagomenae are not to be marked in a superior group*.

As a final result we obtained two mathematical models:

1. for the 1st to 7th year

$$(42 + 8 + 42) + (42 + 8 + 42) + (42 + 8 + 42) + (42 + 6 + 42) = 366 \text{ days}$$

92 days              92 days              92 days              90 days

2. for the 8th year

$$(42 + 8 + 42) + (42 + 8 + 42) + (42 + 8 + 42) + (42 + 42) = 360 \text{ days}$$

92 days              92 days              92 days              84 days

The seasons of the year between December 22nd 2015 and December 21st 2016 have the following (approximate) durations: winter - 88.99 days; spring - 92.75 days; summer - 93.66 days; autumn - 89.85 days. They are very similar with the values found through our model.

We may suppose that the calendar in the 7th sanctuary - if exists - is a seasons calendar, important in an agrarian society. Spring, summer and autumn were considered equal, while winter was variable.

An eight-year cycle is well known in Mediterranean world; Greek cities had transmitted it to Rome, where it evolved to our four-year period. In Athens it seems that the eight-year calendar was in use since Cleisthenes, if its author is in fact Cleostratos of Tenedos<sup>8</sup>, to be modified by Meton about 76 years later.

---

<sup>8</sup> Censorinus in *Filosofia greacă până la Platon*, vol. 1/2, p. 390.

Josephus draw a parallel between the Essenes and Dacians; we know now that Essenes had a solar year of 364 days, rectified once in 49 years.

It cannot be established if the "epagomenae" were of "fas" nature or not. Their character was ambivalent always and everywhere. Julius Caesar established the day *bisextilis* as "fas" but Valentinianus delayed his proclamation as Augustus only to avoid it<sup>9</sup>. Whatever their nature, they have undoubtedly a peculiar importance in Dacian calendar.

#### 5.The greater circular sanctuary - a general view.

The sixth sanctuary - known also as "the greater circular sanctuary" or as "the calendar sanctuary" - has a complex structure. The now extant part raise a number of still unanswered questions, from building details to its meaning and purpose.

The sanctuary<sup>10</sup> consists of three concentric rings and an apsidal construction in the middle. The two exterior circles are joined together and are built of andesite.

The outer ring has a diameter of 29.40 m (= 96.5 ft) and it is made from 104 blocks, 99 still in place.

The inner ring has a diameter of 28.02 m (= 92 ft) being a succession of 30 groups of 6 taller pillars with tenon + 1 wider block - the same as in the 7th sanctuary. Their total number of elements is 210, from which 180 are taller and thinner pillars with tenon.

The third circle consists of 84 wooden posts/pillars, divided in four sections by doorsteps of andesite blocks. The underground part of the posts has an average diameter of 40 cm and went deep to 1.45 m. Their visible part was shaped as a quadrilateral prism, covered with decorative ceramic pieces and had ornamental

---

<sup>9</sup> Ammianus Marcellinus, XXVI, 1, 7. When associated with the birth of gods, the supplementary days bear their good/bad character.

<sup>10</sup> The following date are from H. Daicoviciu, *Dacia de la Burebista la Decebal*, Editura Dacia, Cluj-Napoca, 1972 and I.-H. Crişan, *Spiritualitatea geto-dacilor*. The authors do not indicate all the details of the sanctuary but some can be obtained from the map of the site in the prof. Daicoviciu's book; only the number of wooden pillars in the third ring has to be corrected from 68 to 84.

nails fixed in the poles; the maximum number of nails found on a single wooden pillar is 13. That will be the number I will take into consideration in calculus, because it is logic to imagine an initially equal display of the nails, affected later by the vicissitudes of history. The inner diameter of this circle is 20 m<sup>11</sup> (= 65.6 ft).

The absidal construction may be inscribed in a square with sides of approximate 9 m (= 30 ft). Its limits are marked by 34 wooden pillars, divided into two sections through two doorsteps. The north-western/ the apse part has 21 wooden poles, while the south-eastern/right angle part has 13. The pillars have the same decoration as the third ring, but they deep into the ground only 1 m, therefore they were shorter. The number of the still existing nails was not specified by prof. Daicoviciu. An open fireplace was found outside the building, nearby its south-eastern corner, with few marks of fire.

The 6 stone doorsteps and the apse form the axes of the wooden complex. The entrances 1-2-3-4 are on the compass directions 30° - 210°. The doorsteps 2 and 3 - situated in the absidal building - are made of 2 andesite blocks, while the first and fourth - located in the third circle - have 3 blocks each; nevertheless they are equal: 1.30 m in width. Outside the sanctuary but in front of the first entrance there is a stone platform made of 20 irregular blocks, measuring 2.30 x 2.30 m; due to the fact that there is a distance of 60 cm between the first circle and the platform, I think that a few wooden steps made possible the access inside the building.

The 6th doorstep, the extreme point of the apse and the 5th doorstep draw the main axis of the sanctuary on compass directions 120° - 300°. The doorsteps are part of the third ring, they have a width of 2.20 m and have 4 blocks each; therefore they were named "the larger doorsteps".

The wooden parts of the 6th Sanctuary are burned to coal as all the other buildings of the sacred zone of Sarmizegetusa; they were destroyed by the Romans during the second Dacian war.

Evidently, it is not by accident that we have an arithmetic progression (2-3-4 blocks in the doorsteps), a proportion between the smaller and greater doorsteps ( $\approx 0,6$ ) that nears the "golden number" 0.618 and the relation

---

<sup>11</sup> The exterior diameter would be with  $\approx 60 - 80$  cm greater.

the diameter of the 3rd circle + the side of the absidal structure  $\approx$  the diameter of 1st circle.

The archaeologists have noted that 29.40 m may be seen as 100 Roman *pedes*. The debate if we have or not sufficient data to reconstruct the Dacian system of measurements continues and, in my opinion, it will remain open for a long time. It is not the goal of this paper to attain this area of research; however, I will say that at this moment I consider plausible an equality

the diameter of the greatest circle = 100 Roman *pedes* = 60 Dacian cubits = 29.40 m

There are a number of hypothetical reconstructions of the 6th sanctuary; they represent variants of three main points of view:

1. Prof. Hadrian Daicoviciu believed that the Dacian religion was centered on Sun and Sky. Therefore he saw the sanctuary as a structure without roof, all the constitutive elements of the construction being visible. The pillars of the 3rd circle had the height of 3 m above the ground, while those of the absidal construction had only 1.5 - 2 m. The scientist admitted an open structure would have inconveniences during winter, but he argued that it was of seasonal use.

2. The architect Dinu Antonescu devised a central temple with a tile roof; a wooden floor covered the entire surface of the 1st circle, each beam being fixed in a tenon of the thinner pillars.

Arguing for a slightly different variant, Prof. Ion-Horațiu Crișan based his plea on images from Trajan's Column, as well as on Roman and - especially and very emphatically - on Celtic parallels. The absidal building would have been higher than the 3rd wooden ring, as a result, there were two roofs: one for the central construction and the other for the lower part.

3. Ion Glodariu and Mihaela Strâmbu offered a solution to roof the 3rd circle using rafters<sup>12</sup>.

---

<sup>12</sup> See a drawing in I. Glodariu, *Arhitectura dacilor – civilă și militară – (sec II î. e. n. – I e.n.)*, Editura Dacia, Cluj-Napoca, 1983.

The following facts challenge the second form of reconstruction in both its variants:

In the 6th Sanctuary were no findings of tiles as in the 7th Sanctuary; a continuous wooden floor and a central construction of the supposed size would have produced a more significant amount of ashes than reported<sup>13</sup>; the wooden pillars were deepened at different level, so their heights were also different; the tenon of a thinner stone pillar could support any type of capital and the second ring should have to be visible, because it was the boundary between the sacred space and the lay area.

I consider that the problem of the roof is not solved but, for now, the variant with rafters is more plausible.

## 6. An astronomical model for data regarding the Sun.

The previous pages showed us the limits within we are allowed at this moment to construct plausible theories.

We will begin from the alleged "solstice orientation" of the greater sanctuary; it would be more accurate to say that is the orientation of the main axis, the one through apse.

We will use the general equation<sup>14</sup>

$$\sin y = \sin \varphi \sin \delta + \cos \varphi \cos \delta \cos T$$

$y$  = the altitude of the sun/star/planet

$\varphi$  = the latitude of the place of the observation

$\delta$  = the declination of the sun/star/planet

---

<sup>13</sup> The stone platform in front of the first entrance bears much more important marks of fire than the interior of the sanctuary.

<sup>14</sup> V. Fiona Vincent *Positional Astronomy*, chapter *Sunrise, sunset and twilight*, electronic edition of lectures at St. Andrews in 1998. The hour angle is measured in hours westwards from the meridian of the place, the one in direction of geographical South, to the celestial meridian of the star. I have simplified as much as possible the explanations and I transformed the time units into degrees: 1 hour = 15°, 1 min = 15', 1 s = 15".

$T$  = the hour angle.

At the meridian the sun/star/planet is at the highest altitude and its geographical direction is South  $=180^\circ$ . When it sets, the altitude is  $0^\circ$  and the direction is

$T=180^\circ + x$ . When it rises the direction is

24 hours -  $T=360^\circ - (180^\circ + x) = 180^\circ - x$ . The two angles are equal. The equation becomes

$$\cos(180^\circ \pm x) = -\tan \varphi \tan \delta$$

When  $y < 0^\circ$  the star is below the horizon; when  $-18^\circ < y < 0^\circ$  we refer to different types of twilight.

The latitude of Sarmizegetusa is

$$\varphi = 45^\circ,6224445 \text{ N} = 45^\circ 37' 20'',8 \text{ N}$$

the main declinations of the sun are  $\delta=0^\circ$ , at equinoxes, when apparently crosses the Equator, and  $\delta = \pm \varepsilon$ , at solstices, when the absolute value of  $\delta$  equals the angle between the Ecliptic and the Equator, noted as  $\varepsilon$ .

The value of  $\varepsilon$  diminishes with time. The values calculated by the International Astronomical Union are

$\varepsilon$  = Earth obliquity for year 2000

$$\varepsilon_{J2000} = 23^\circ 26' 21'',406 = 84\,381'',406$$

rate of change of  $\varepsilon$  per Julian century( = 36525 days)

$$\Delta\varepsilon = -46'',836769/\text{Julian century}.$$

Since January 1st 2000, 12 hours Universal Time, is Julian Date 2 451 545, and January 1st 100 AD, 12 hours UT is JD 1 757 583, the time difference is

$2\,451\,545 - 1\,757\,583 = 693\,962 \text{ d} = 18.999\,644\,079\,398 \text{ Julian centuries}$ , therefore

$$\varepsilon_{J\,100} = 84\,381'',406 + (46'',836769 \times 18.999\,644\,079\,398) = 85\,271'',2879\,408\,3 = 23^\circ.686\,468\,872 = 23^\circ 41' 11'',288$$

a value that can be used for any year of the 1st century.

The following calculus concerns only the entrances and doorsteps 5,6 and 4, the directions where the Sun can be observed from. The entrance 1 was considered a simple way of access, if an observation would have been intended it would regarded only the stars that are allways visible ( $\delta \geq 44^\circ 30'$  at that latitude).

The interior diameter of the third circle being 20 m, the doorsteps represents chords for arcs, as follows:

- the larger doorsteps

$a_{\max} = 2 \arcsin(2.2/20) = 12^\circ.63063$ ; the average width for each of the four stoneblocks is  $3^\circ.16$ ;

- the smaller doorsteps

$a_{\min} = 2 \arcsin(1.3/20) = 7^\circ.453\ 706\ 284\ 9$ ; the average width for each of the three stoneblocks is  $2^\circ.48$ .

The results, in a concised form, are:

1. The traditional supposition that the direction of the apse ( $300^\circ$ ) indicates the sunset at summer solstice is only partialy true; the Sun sets at  $296^\circ.636\ 222\ 562\ 9$ . The extreme points of the 5th doorstep are at (in average)  $293^\circ.7$  și  $306^\circ.3$ , so the sunset point was in front of the first stoneblock. The last one is placed between  $303^\circ$ - $306^\circ$ , the altitude of the Sun at this hour angle being  $-5^\circ$ ; in the direction of the main axis the altitude was roughly  $-2^\circ$ , so we may consider the 5th doorstep a standard mesure for the twilight in the longest day of the year.

2. The 6 th doorstep, situated between  $113^\circ.7$  -  $126^\circ.3$  and symmetrically opposed to the 5 th, is better adapted for the winter solstice. At  $120^\circ$  - on the main axis - the Sun was easy to see at winter solstice, with an altitude of  $2^\circ$ . The diurnal arc of the Sun for the winter solstice in 1st century at this geographical latitude was

$$126^\circ.727\ 554\ 874\ 528 = 506.91 \text{ min.}$$

The  $12^\circ.63063$  doorstep represents a period of 50.5225 min very near from 1/10 of the diurnal arc; to be a perfect standard the doorstep width should mesure 2.207 m.

3. The direction of the fourth entrance is  $210^\circ$  and the altitudes of the Sun at the important days are

$$\text{Equinoxes} \quad \delta=0^\circ \quad x=30^\circ \quad y=37^\circ.278\,063\,428=37^\circ16'41''$$

$$\text{Summer solstice} \quad \delta = \varepsilon \quad y=57^\circ.330\,235\,521=57^\circ19'48''.848$$

$$\text{Winter solstice} \quad \delta = -\varepsilon \quad y=15^\circ.516\,935\,508\,2=15^\circ31'$$

To be possible that a sunshine could attain the middle of the 3rd circle in the absidal structure the minimal height of the door must be

$$R \tan 15^\circ 31' = 10 \times 0.277\,643 = 2.77 \text{ m} \quad R = \text{radius}$$

The width of the doorstep is  $7^\circ.453\,706\,284\,9$  that represents in time units

$29 \text{ min } 48.534 \text{ s} = 1/24$  of daylight at equinoxes; to be a perfect standard the doorstep width should measure 1.31 m.

4. In order that a sunshine could attain the apsis through the 6th entrance,  $y$  must be

$y = \arctg z/d$ , where  $z$  = the height of the poles that form the wall, the construction is presumed to be without a roof, and  $d$  = the distance between the apsis and the wall in front. Both are unknown values; based upon the sketch of the sanctuary, the exterior length of the structure is estimated to be 9 m, from which the diameter of the poles (40 cm) must be subtracted, and as a result the distance is  $\approx 8.6$  m. The distance from the apsis to the 6th doorstep, measured on the longer axis, is estimated to be  $\approx 15.64$  m; the door height is  $15.64 \tan y$ .

The height  $z$  is estimated between 1.50 and 2 m, and the extreme values are

$$y_{\min} = \arctg (1.5 : 8.6) = \arctg 0.1744186047 = 9^\circ.8939207 = 9^\circ53'38''.1144$$

for which the door is 2.73 m high;

$$y_{\max} = \arctg (2 : 8.6) = \arctg 0.23255814 = 13^\circ.091893064 = 13^\circ05'30'',815$$

for which the door is 3.64 m high.

The minimal height is very near of the one obtained at point 3 for the fourth entrance. Therefore

$$\delta_{\min} = -11^{\circ}.461154064 = -11^{\circ}27'40''.1546$$

but all the angles are measured from the center of the Sun, as required by modern astronomy. To have the ancient angles we must add the angular semidiameter of the Sun and the refractive index, a total of 23', so the height of the poles is 1.56 m and all the entrances will be  $\approx 2.80$  m high.

$\delta = -11^{\circ}28'$  corresponded in 2015 with February 19th and October 23rd, very near to the important feast days in the traditional Romanian calendar *Dragobete* (February 24th) and *Saint Demetrius* (October 26th). We must observe that the two dates are at  $\pm 30$  days from the equinoxes, and in February the day can be used to establish the moment of the spring equinox.

## 7. Some astronomical data regarding the Moon. The estimated construction date.

Previous chapter saw the 6th sanctuary in its relationship with the apparent movement of the Sun. There are three reasons to do the same thing for the Moon:

1. assuming that a eight year cycle existed, it would have sense only if it was used to obtain a concordance between the tropical and the synodical year, because

$$8 \text{ tropical years} = 2922 \text{ days} \approx 99 \text{ synodical months}^{15}$$

2. the mathematical interpretation of data in the 8th chapter shows, among others results, a proportion between the sidereal and synodical revolution of the Moon.

3. the main axis of the central structure indicates the setdown point for an object with a greater declination than the Sun. The limit of the 5th doorstep is  $306^{\circ}$ , that gives us  $\delta \approx 30^{\circ}$ . We must remember that the 2nd circle has its own height; therefore an object that sets at  $306^{\circ}$  is last visible at  $300^{\circ}$ , where its altitude is roughly  $3^{\circ}$ .

The maximum angle between the orbit of the Moon and the Ecliptic is  $5^{\circ}18'$  and added to  $\epsilon$  makes possible  $\delta = \pm 29^{\circ}$ . To have  $\delta = 29^{\circ}$  means that the ascending node of the satellite and the vernal node coincide, the right ascension of the Moon is 6 hours and its ecliptical longitude is  $90^{\circ}$ , at that time being seen in Cancer, its

---

<sup>15</sup> The average is  $2922 : 99 = 29.5151$  days for the synodical month.

astrological "home". Such a phenomenon is uncommon, it can be observed only 5-6 times in a century. The ascending node has a retrograde movement, its longitude varying with  $-0^{\circ}.052954$  /day<sup>16</sup>; therefore the tropical revolution of the node is 6798.353 287 759 2 days = 18 years 224.353 days.

The possible days when the Moon had the maximum declination and was observed in the sign of Cancer were:

November the 1st and 2nd of the year 14;

June the 17th and 18th of the year 33;

February the 1st and 2nd of the year 52;

September the 17th and 18th of the year 70;

May the 3rd and 4th of the year 89.

Only the last two could be concordant with the accepted estimations; the archaeologists suggest in fact a date later than 90 AD.

I consider that, if the previous astronomical hypothesis is true, the year 70 is more plausible than 89. The reasons are:

- As far as we know, the year 70 was a peaceful one, very likely the reign of King Duras was just beginning. We do not know if in May 89 the truce/peace between Romans and Dacians was agreed; in fact this is the only argument for a date after 90.

- During the reign of Decebal a small quadrilateral sanctuary was built in such a way that any observation through the 5th entrance was impossible. That proves the 6th sanctuary was an earlier construction; actually, the buildings still in progress at the beginning of the war in 101 were quadrilateral and only with andesite components. The sanctuaries 6th, 7th and the altar called "the andesite Sun" form

---

<sup>16</sup> *The Astronomical Ephemeris 1967= The American Ephemeris and Nautical Almanac for the year 1967*, London - Washington, 1965, p. 51. The following calculus has the reference position at 1966, December 31st, 12 hours 00 min UT= 1967, January 0. The results for the 1st century have an approximation of maximum  $0^{\circ}.5$ ; for the configurations I used data from Swiss Ephemeris.

a group on its own, that differs in position, form (circular) and construction materials (a mix of wood and stone elements).

- From an astronomic point of view, September 18th 70 is more interesting than any of the other days. There were 1. a conjunction between Moon and Mars, forming a quadrangle with Saturn in Libra, 2. a conjunction between Venus and Mercury, 3. the Moon was in the last quarter.

- The results regarding the Sun from the previous chapter argue for observations made from September to March. Very likely in autumn and winter of the year 70 the field was marked out, but the building work was done in the warm season of 71.

#### 8. The mathematical model for short and medium periods of time.

The mathematical models created for the greater sanctuary have in common three assumptions:

- all the elements of the construction (wooden pillars, tall andesite pillars, stone blocks of the first circle, doorsteps and decorative nails) have a mathematical relation with one another;
- they are representing periods of time or multipliers to these periods;
- their meaning is the representation of the Dacian calendar.

All the models devised till now considered that

- 1 thinner pillar with tenon = 1 day;
- 6 pillars = 1 "Dacian week" or "*sextimana*";
- 180 pillars = 180 days =  $\frac{1}{2}$  Dacian year;
- the elements (3-4 blocks of stone) of the doorsteps are "multipliers" and the nails from the 3rd ring are marks for calendar.

I consider that we have a rather good calendar in the 7th sanctuary, therefore we should see the greater sanctuary from a different perspective, an astronomical one.

I considered the wooden pillars of the 3rd circle as representing successively 1 day, 6 days, 180 days; only for the value of 180 days the results are significant.

This fact showed that the second ring of thinner andesite pillars to be a time standard: 180 pillars = 180 days. The exterior circle has 104 blocks; they have some small dimensional variations, but as time units I regarded them as equals: 1 block = 2 x 180 days = 360 days. This period should be interpreted not as a year of 360 days but as 60 x 6 days in a sexagesimal numeration system.

I will refer to "multipliers" in the following chapter.

As I insisted presenting the details of the sanctuary, the first and second ring form an unit on its own right, therefore it must be treated as such.

104 blocks x 360 days = 37 440 days

180 pillars x 1 day = 180 days

Total = 37 620 days

103 tropical years x 365. 242 199 (074) d = 37 619.946 504 (629) d

37 620 - 37 619.946 504 = + 0.053 496 z = + 1 hour 17 min 02 s

Which leads to an error of 45 s/year.

We may then consider the first two circles as representing

209 x 180 days = 103 tropical years.

We must have a twofold interpretation of the central structure, because we have to see it first as a total with its 34 wooden pillars and at same time as two independent parts with 21 and 13 columns.

The calculus is

$$34 \times 180 \text{ z} = 6120 \text{ days}$$

$$21 \times 180 \text{ z} = 3780 \text{ days}$$

$$13 \times 180 \text{ z} = 2340 \text{ days.}$$

A period of 6120 days is a very interesting lapse of time because it could represent a relationship between the sidereal and the synodical revolution of the Moon.

$$1 \text{ sidereal revolution of the Moon} = 27 \text{ days } 07 \text{ hours } 43 \text{ min } 11.5 \text{ s} = 27.321660879(629) \text{ d}$$

$$6120 \text{ d} = 223.998 \, 095 \, 393 \text{ revolutions} \approx 224 \text{ revolutions}$$

$$6120 : 224 = 27.321 \, (428571) \text{ z} = 27 \text{ days } 07 \text{ hours } 42 \text{ min } 51.43 \text{ s}$$

that means an error of - 20s /revolution.

It is meaningfull that if we add all the elements in the sanctuary with the supposed value of 180 days and equal them with 784 sidereal revolutions, we will obtain the same duration:

$$(34 \times 180) + (84 \times 180) + 180 = 21 \, 420 \text{ d}$$

$$21 \, 420 : 784 = 27.321 \, (428571) \text{ d.}$$

$$1 \text{ synodical revolution of the Moon} = 29 \text{ days } 12 \text{ hours } 44 \text{ min } 02.8 \text{ s} = 29.530 \, 587 \, (962) \text{ z}$$

Dividing 6120 days with this value we obtain 207.242 741 synodical revolutions but the two doorsteps have together 4 blocks; if they are to be seen as multipliers we could consider a total of  $\approx 829$  synodical revolutions and thence

$$6120 \times 4 = 24 \, 480 \text{ days}$$

$$24 \, 480 : 829 = 29.529 \, 553 \, 679 \text{ days} = 29 \text{ days } 42 \text{ min } 33.44 \text{ s}$$

That means an error of -1 min 29 s/lună<sup>17</sup>.

We have the final relation between the two movements

896 sidereal revolutions = 829 synodical revolutions/months.

In order that the following part to be completely understood, it must be explained the meaning of the syntagma "synodical revolution of a planet"<sup>18</sup>.

The synodical revolution or period is the lapse of time needed that, as seen from the Earth, a planet and the Sun form the same angle, especially the same remarkable configuration (conjunction, quadrature or opposition).

If  $P_3 = \frac{2\pi}{\omega_3}$  is a sidereal year and  $P_n = \frac{2\pi}{\omega_n}$  the sidereal period of planet  $P_n$ , the synodic period of  $P_n = P_{\text{syn}}$  is

$$\frac{1}{P_{\text{syn}}} = \left| \frac{1}{P_3} - \frac{1}{P_n} \right| = \frac{|\omega_3 - \omega_n|}{2\pi}$$

$$2\pi = 1\,296\,000''$$

The average sidereal daily movement of the Earth is  $P_3 = 3\,548''.192\,780\,628\,776$

that of Mars  $P_4 = 1886''.52$

that of Saturn  $P_6 = 120''.45$

Thence we have for Mars

$$P_{\text{syn}4} = 1296000'' / (3548''.192\,780 - 1886''.52) = 779.9369500414 \text{ days}$$

and for Saturn

$$P_{\text{syn}6} = 1296000'' / (3548''.192\,780 - 120''.45) = 378,0913\,806 \text{ days.}$$

---

<sup>17</sup> The movements of the Moon, therefore also its revolutions, are not entirely regular. The above values are the average ones.

<sup>18</sup> See Dr. J. B. Tatum, *Celestial Mechanics*, chapter 8.8 (electronic source), 2015 . For the sidereal movements of the planets, see *Anuarul astronomic 1983*, Editura Academiei, Bucureşti, 1982, pp. 86 - 87.

It is obvious that the 3780 days represented by the 21 pillars of the apse are equal with 10 synodical revolutions of Saturn and that at the end of the period a day must be added. We might suppose that at the beginning and ending of that interval the Moon and Saturn form the same apparent configuration.

From ancient times to present day the synodical period of Mars is usually rounded to 780 d and

$780 \times 3 = 2340$  days represented by the 13 pillars from the south-eastern part of the central structure.

#### 9. The mathematical model for long and very long periods of time.

The third circle consists of  $4 \times 21$  wooden pillars, with 13 nails each and 4 doorsteps with 3, 3, 4, 4 blocks as multipliers. If, as previously supposed, each pillar represents 180 days, marked each 13 times, then

$$84 \times 13 \times 180 \text{ days} = 196\,560 \text{ days}$$

$$196\,560 : 378 = 520 \text{ synodical periods of Saturn - usual value}$$

$$196\,560 : 378,091\,380\,6 = 519,874\,321\,620 \text{ real synodical revolutions}$$

Difference

$$(519,874\,321\,620 - 520) \times 378,091\,380\,6 = -47,517912 \text{ days}$$

For Mars we have

$$196\,560 : 780 = 252 \text{ synodical periods - usual value}$$

$$196\,560 : 779,9369500414 = 252,020\,371\,633 \text{ real synodical revolutions}$$

Difference

$$(252,020\,371\,633 - 252) \times 779,9369500414 = 15,888\,589\,6 \text{ days}$$

The calculus proves that at the end of this long period of time the two planets do not form the same configuration with one another, nor with the Sun, as in its beginning but

$$15.888\ 589\ 6 - (-47.517912) = 63.406\ 501\ 6\ \text{d}$$

$$378.091\ 380\ 6 : 63.406\ 501\ 6 = 5.962\ 975 \approx 6$$

$$378.091\ 380\ 6 : 47.517912 = 7.956818 \approx 8$$

I think that we can read this as

"If you want to find again Saturn in a given point in sky, you have to multiply this lapse of time by 8".

"If you want the same configuration between Saturn and Mars, you must multiply this interval by 6".

Therefore we could assume that the grater doorsteps, which have together  $4+4=8$  blocks, are the multipliers for the periods of Saturn and the "smaller doorsteps", with  $3 + 3 = 6$  blocks together, are the multipliers used in order to obtain the concordance between the two planetary periods.

We can write in a more familiar way as

$$520\ \text{Saturn syn. periods} - (520 \times 378\ \text{d}) = 1/8\ \text{syn. revolution of Saturn}$$

$$520\ \text{Saturn syn. periods} - 252\ \text{syn. periods of Mars} = 1/6\ \text{revolution of Saturn}$$

This is the same as

$$4159\ \text{Dacian synodical revolutions of Saturn} = 4160 \times 378\ \text{d} = 1\ 572\ 480\ \text{days}$$

$$3119\ \text{Dacian synodical revolutions of Saturn} = 1512\ \text{Dacian synodical revolutions of Mars}$$

Thence

$$1\ \text{Dacian synodical revolution of Saturn} = 378.09088723250\ \text{days}$$

$$1\ \text{Dacian synodical revolution of Mars} = 779,93748497235\ \text{days}.$$

But

1 572 480 days : 378.091 380 6 days = 4 158.994 573 true synodical revolutions of Saturn, the difference is

- 0.005427 x 378.091 380 6 = - 2.051917 days

The final errors of that calculus for a single synodical period are

- for Saturn:

378.090 887 2 - 378.091 380 6 = - 0.000 493 4 d = - 42,63 s

- for Mars:

779.937 484 972 4 - 779.936 950 041 4 = + 0.000 534 931 d = + 46,22 s

I must emphasize that these very long periods of time must not be seen as an indication of direct observations; their role is just to give a ratio

1 synodical period of Mars = 3119/1512 synodical periods of Saturn.

If a time projection was intended, it was towards the past not to the future; very likely, if the case, towards the mythical moment of the genesis of the world. 1572480 days  $\approx$  4305 Julian years, therefore, if this very bold assumption would be true, the Dacian mythical beginning was situated somewhere between 4235 - 4215 BC.

By using all the multipliers in the third circle will result a maximum period of time:

180 x 84 x 13 x (3+3) x (4+4) = 9 434 880 days = 25 831.845 345 139 tropical years.

This value nears very well the duration of the "platonian year":

the average precession in longitude of the vernal node: 5028".796 195/36525d

1296000" x 36525d/5028".796 195 = 9 413 067,892285104d = 25 772,125 773 386

tropical years, that means a difference of 59.72 years or 0.23%.

The result is just a mathematical possibility, it does not imply an actual knowledge among Dacian people of the "platonian year" and any further speculations have no object.

The previous models regard only the Sun, the Moon and the planets Mars and Saturn but that does not imply in any way that Dacians simply ignored Mercury, Venus or Jupiter. Probably is just the archaeological hazard, due only to the partial conservation of the sanctuaries. We must remember that in ancient times some very simple ratios were in use to approximate these periods:

5 syn. periods of Venus = 8 Julian years - 2 days

5 sidereal revolutions of Jupiter  $\approx$  2 sidereal revolutions of Saturn

and such (or similar) relations had to be known among Dacians.

#### 10. The meaning and value of the results.

We must interpret these results and put them into the context of Dacian culture.

They are compatible with the knowledge level of the Greco-Roman world and that makes them plausible (= they are not impossible).

Excepting a possible relation

$2 \times 209 \times 180 \text{ days} = 206 \text{ tropical years} \approx 2754 \text{ sidereal revolutions of the Moon} \approx$

$\approx 2548 \text{ synodical months} \approx 2765 \text{ Draconitic months}$

I could not find any connection with the calculus of the eclipses as Jordanes suggested.

The models presented can be considered as successful because:

- in the seventh sanctuary we obtained a eight year calendar, well adapted for a rural society depending on seasons regular succession;
- in the greater sanctuary we have found ratios between the apparent planetary movements, most of them very accurate.

A very long time was needed to gain these data, it was the work of generations of Dacians who observed the sky.

Obviously, the "platonic year" is out of discussion but the period of 196 560 days ( $\approx 538$  years) may be a real one, that could indicate the beginning for the observation on movements of Saturn and Mars at latest about the same time with Herodotus' travel in Getia.

We must avoid to perceive the four celestial bodies from the perspective of the Greek and medieval astrology; probably for the Dacians Mars and Saturn were not "maleficient planets".

Assuming the planets were selected on bases of the relationship with the deities from the Dacian pantheon (or general Thracian) a few hypotheses can be developed.

Bendis was a goddess of the Moon in Thracia; it is sure that she (or a similar deity) was honoured also in Dacia and Moesia. Mars was the planet of Ares since the time of Homer.

Saturn is much more interesting, its leading role being very surprising indeed. The explanation may be a fragment from Mnaseas, surviving in Photius and Etymologicum Magnum: "the Getae honour Kronos (= "the time" Et<ymologicum> M<agnum>) naming him Zamolxis"<sup>19</sup> but the Greek god Kronos was assimilated by the Romans with the indigenous Saturnus. Therefore we can consider Saturn as the planet of Dacian Zamolxis/Zalmoxis; if true, this correspondence was established in the 8th century BC, when the ascending node of the planet had the ecliptic longitude of  $90^\circ$  and as a result its movement was very near from the apparent orbit of the Sun.

It may be concluded that the goals of this paper are reached and the theory presented is plausible, comprehensive and flexible enough; time will tell if the hypotheses can be verified.

---

<sup>19</sup> *Izvoare privind istoria României*, Editura Academiei, Bucureşti, 1964, vol. I, p. 157.